# The Relationship Between Tooth Mineralization and Early Radiographic Evidence of the Ulnar Sesamoid

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Genetic and racial diversity and environmental influences have a marked effect on the rate of development of the prepubertal child and adolescent with the result that chronological age need not necessarily reflect the progress which an individual has made toward physiological maturity. A more accurate assessment of physical development may be made by the radiographic examination of the calcified structures of the hand and wrist from which the degree of maturity of individual bones may be assessed, and the skeletal age determined by comparison with published radiographic standards.[7,14]

Previous investigations have shown that adolescent peak growth velocity in body height is closely related to certain events which occur during the course of development of the hand and wrist. The onset of ossification of the ulnar sesamoid of the first metacarpophalangeal joint is closely related in timing with the adolescent spurt in statural height.[2,3,8] However, little is known of the relationship between the onset of peak velocity growth and dental development.[13] Studies have shown that correlations between tooth mineralization and other parameters of maturation are generally low,[1,9] while there is no more than slight correlation between tooth eruption and the adolescent growth spurt.[11] The present study investigates the relationship between the stages of mineralization of various teeth and the early radiographic evidence of calcification of the ulnar sesamoid of the first metacarpophalangeal joint among South African Caucasoid boys and girls.

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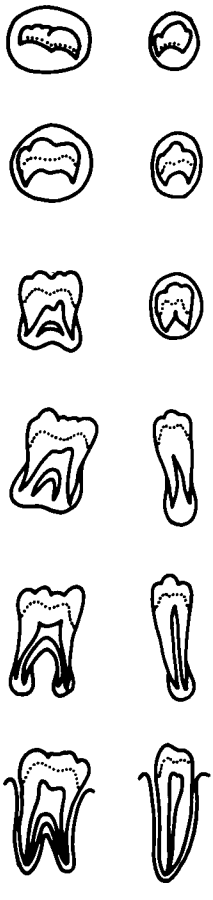
## METHODS AND MATERIALS

Data used in this study were obtained from the records of one hundred and forty individuals – ninety three girls and forty seven boys, taken from the files of a private orthodontic practice and the Orthodontic Department of the School of Dentistry, University of the Witwatersrand. All participants, none of whom had received orthodontic therapy, were of Caucasoid extraction, well-nourished, and free of any known serious illness.

Fig. 1

DESCRIPTION OF EACH STAGE OF TOOTH CALCIFICATION USED IN THIS STUDY



| | |
|---|---|
| STAGE C. | a) Enamel formation is complete at the occlusal surface.<br>b) Dentine formation has commenced.<br>c) The pulp chamber is curved. No pulp horns are visible. |
| STAGE D. | a) Crown formation is complete to the level of the amelocemental junction. Root formation has commenced.<br>b) The pulp horns are beginning to differentiate but the walls of the pulp chamber are curved. |
| STAGE E | a) The root length is less than the crown height.<br>b) The walls of the pulp chamber are straight and the pulp horns are more differentiated.<br>c) In molars the radicular bifurcation is visible. |
| STAGE F. | a) The walls of the pulp chamber form an isosceles triangle.<br>b) The root length is equal to or greater than the crown height.<br>c) In molars the bifurcation has developed sufficiently to give the roots a destinct outline. |
| STAGE G. | a) The walls of the root canal are now parallel but the root apex has not yet closed.<br>b) In molars the distal root is assessed. |
| STAGE H. | a) The root apex is completely closed ( distal root in molars ).<br>b) The periodontal membrane surrounding the root and apex is uniform in width. |

TABLE I

Panoramic roentgenographic views of the jaws and teeth, and left hand wrist radiographs were examined. The criterion for selection of participants was based on the appearance of a calcified ulnar sesamoid of at least 1 mm in diameter (Fig. 1).

A skeletal age was ascribed to each individual using the T.W. 2 method described by Tanner, Whitehouse, Marshall, Healy and Goldstein.[14] The panoramic radiographs were examined and tooth mineralization on the left side rated according to the method described by Demirjian, Goldstein and Tanner in which eight stages of formation, A to H, are described for each tooth.[4] The range of the stages ascribed to the state of development of the teeth used in this study varied from C to H. A description of each of these stages is given in Table I.

The maxillary posterior teeth were omitted from the study because superimposition of calcified structures in this area rendered accurate assessment of the state of development of these teeth virtually impossible. Incisors

TABLE II
DISTRIBUTION OF CALCIFICATION STAGES OF THE TEETH

| Stage | Boys | | | | | Girls | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | U-3 | L-3 | L-4 | L-5 | L-7 | U-3 | L-3 | L-4 | L-5 | L-7 |
| C | — | — | — | — | — | — | — | — | — | 1 |
| D | — | — | — | — | — | — | — | — | — | 2 |
| E | — | — | 2 | 2 | 4 | — | — | 4 | 14 | 19 |
| F | 2 | 1 | 4 | 11 | 13 | 17 | 6 | 36 | 50 | 49 |
| G | 28 | 36 | 8 | 18 | 20 | 60 | 72 | 33 | 21 | 19 |
| H | 15 | 10 | 31 | 16 | 10 | 11 | 15 | 19 | 5 | 3 |
| Total | 45 | 47 | 45 | 47 | 47 | 88 | 93 | 92 | 90 | 93 |

and first molar teeth were not rated because apical closure had already taken place in all the subjects selected. Third molars were also excluded from the study. The teeth examined were thus the maxillary and mandibular canines, mandibular first and second premolars and mandibular second molars.

The distribution of the various stages of root formation for each of the teeth studied is shown in Table II. It should be noted that congenital absence of the lower first premolar occurred in three children, while agenesis of the mandibular second premolar was found in the same number of cases. In seven subjects the state of development of the maxillary canines could not be assessed accurately because of superimposition of other calcified structures over the developing root. These seven teeth were excluded from the sample.

## Statistical Methods and Results

The mean chronological and skeletal ages of both male and female participants in the study together with their standard deviations were calculated (Table III) to determine the variation in age of the earliest calcification of the adductor sesamoid.

The Chi-square statistic was applied to the data in Table II for the purpose of testing whether the distribution of the various stages of root formation (C to H) was similar among the teeth studied. In the analysis, stages C and D were combined with stage E to provide a sufficiently large cell size to ensure the validity of the Chi-square test. Separate analyses were carried out for boys and girls after which the combined sample was tested.[10]

Chi-square values for boys and girls as well as the combined sample were highly significant at the 1% probability level. In all cases the major contribution to Chi-square came from stages F and G of the mandibular canine indicating that the observed distribution of stages of mineralization of this tooth differs sufficiently from the distribution among the remaining teeth to reject the null hypothesis at the 1% level of confidence. The Chi-square statistic was then applied to test for differences between

TABLE III
AGE (IN YEARS) OF APPEARANCE OF THE ULNAR SESAMOID OF THE FIRST METACARPOPHALANGEAL JOINT

| | Sample Size | Chronological Age | | Skeletal Age | |
|---|---|---|---|---|---|
| | | Mean | S.D. | Mean | S.D. |
| Boys | 47 | 13.33 | 1.08 | 13.31 | 0.51 |
| Girls | 93 | 11.3 | 0.95 | 11.22 | 0.44 |

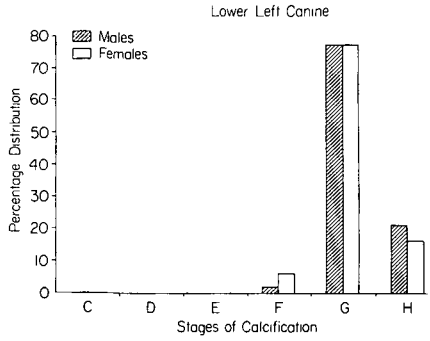



Fig. 2

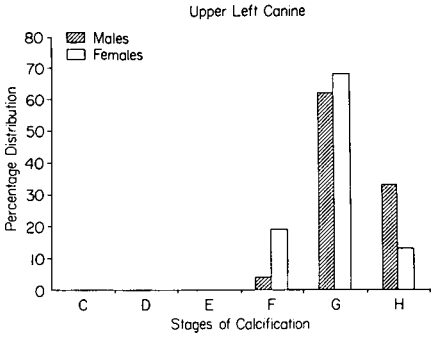



Fig. 3

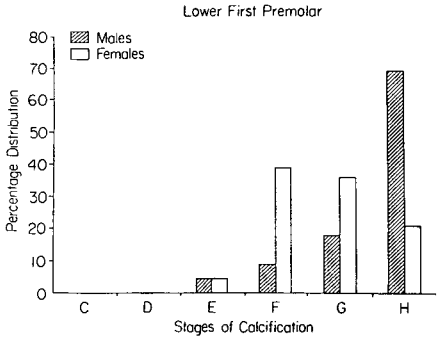



Fig. 4

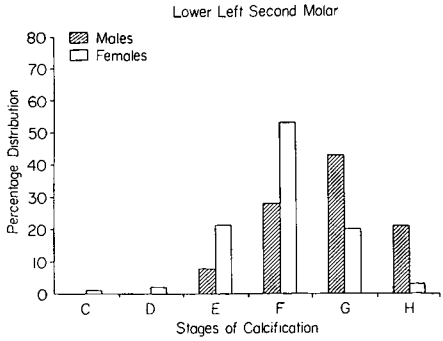



Fig. 5

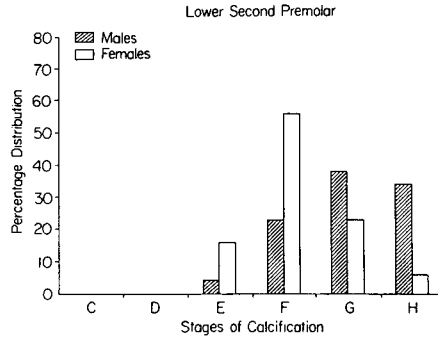



Fig. 6

boys and girls in the distribution of stages of mineralization for each of the teeth studied.

Chi-square values were significant at the 1% level of confidence for all teeth except the mandibular canine indicating a strong sex-specific pattern of mineralization for these teeth. No significant sex differences were evident in the calcification pattern of the mandibular canine. The concentration of the development of the mandibular canine at stage G, compared with the far wider distribution of calcification stages of the remaining teeth, confirms the results of the Chi-square analysis. The similarity in distribution of mineralization stages of the mandibular canine between boys and girls is clearly shown (Fig. 2), while significant sex differences in distribution may be noted for the remaining teeth studied (Figs. 3-6).

## Discussion

The role of the adductor metacarpophalangeal sesamoid of the thumb as a maturity indicator has been described by numerous authors.[2,3,8] Ossification usually commences during

the year prior to, or at the time of, commencement of the pubertal growth spurt. Radiographic evidence of mineralization is easily recognized, even to the uninitiated. Observer reliability is thus high and radiographic quality may vary widely without impairing recognition of early calcification.[12] It is for this reason that the appearance of this ossification centre is commonly used in orthodontic practice to assess the state of maturation of the individual.

The findings of the present study suggest that ossification of the adductor sesamoid commences two years earlier among South African girls when compared with boys, at a mean age of 11.3 years (Table III). Although the standard deviation of the chronological age is approximately one year in both males and females, the standard deviation of the skeletal age is considerably narrower, being approximately 0.5 years. Thus the mean age of early radiographic appearance of the adductor sesamoid in the sample studied did not differ significantly from ages estimated in other growth studies.[6,7,12]

The relationship between early commencement of calcification of the adductor sesamoid and the state of mineralization of individual teeth studied varied from tooth to tooth. In accordance with the findings of Lewis and Garn[9] no close relationship could be shown between skeletal maturation and mineralization of the lower premolar and second molar teeth. The maturational patterns of these teeth varied widely within the sample with a distinct tendency towards an acceleration in the rate of tooth calcification among the boys. However, the ranges of distribution of stages of calcification relating to the maxillary and mandibular canine teeth were far narrower with the majority of teeth having developed to

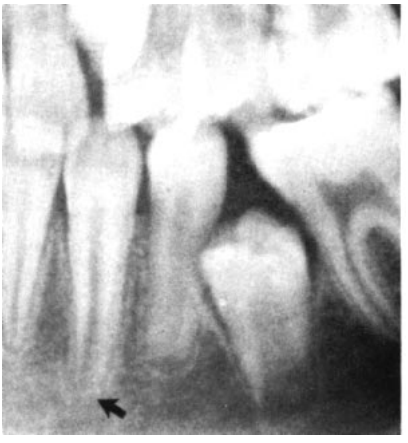


Fig. 7

the stage prior to apical closure, i.e., stage G (Figs. 2, 3). The state of development of the mandibular canine in particular, was closely related to early ossification of the adductor sesamoid with seventy-seven percent of the sample, boys as well as girls, having reached stage G (Fig. 7).

Significant sex differences in the distribution of the stages of tooth mineralization were evident in all the teeth studied with the exception of the mandibular canine. In general, tooth development in boys tended to be accelerated in relation to skeletal maturity when compared with girls. The delay in maturation of the mandibular canine in boys is thus similar in time-span to that noted for skeletal growth and is probably determined by genes on the Y chromosome, the mechanism of expression of which is unknown.[15]

The close relationship between calcification stage G of the mandibular canine and calcification of the sesamoid raises the possibility of the use of this tooth as a maturity indicator for the commencement of the pubertal growth spurt in South African Caucasoid children. Completion of mineralization of the mandibular ca-

nine root prior to apical closure may thus herald the onset of adolescent peak growth velocity in height with a similar degree of confidence as the commencement of calcification of the adductor sesamoid. It should be borne in mind, however, that the relationship between skeletal maturation and dental mineralization may vary in different population groups. It is a well-documented fact that dental development is accelerated among the Black races of Southern Africa compared with Caucasoid population groups while skeletal maturation is retarded.[16] For this reason these findings should be applied to other population groups with caution until the relationship between the state of mineralization of the mandibular canine and early radiographic evidence of the adductor sesamoid of the thumb within these population groups has been investigated.


## Summary

The relationship between early radiographic evidence of calcification of the adductor sesamoid of the first metacarpophalangeal joint and the state of maturity of certain teeth was investigated. Data were obtained from the records of one hundred and forty children of Caucasoid origin, comprising ninety-three girls and forty-seven boys.

Calcification of the adductor sesamoid was closely related to the completion of root mineralization of the mandibular canine prior to apical closure. No significant sex differences were noted in the state of maturation of the tooth in relation to this particular stage of skeletal development.

Correlations among the remaining teeth studied were low, the distribution of calcification stages being widely dispersed with significant sex differences evident.

Based on the findings of this study, the completion of root formation of the mandibular canine prior to apical closure may be used as a maturity indicator for the commencement of the circumpubertal growth spurt with a similar degree of confidence as the calcification of the adductor sesamoid of the thumb. It should be noted, however, that racial variations might exist in the relationship between the state of maturity of this tooth and the commencement of mineralization of the sesamoid. Caution should thus be exercised in the application of these findings to other racial groups.



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